Pest Repellents and Disinfectants

General Information

The pest repellents and disinfectants measured for this *Report* include naphthalene, *p*-dichlorobenzene (DCB), N,N-diethyl-3-methylbenzamide (formerly, N,N-diethyl-meta-toluamide [DEET]), and *ortho*-phenylphenol (OPP). Naphthalene and DCB are used as moth repellents and fumigants. DCB is also used as a bathroom deodorizer. Additional sources of naphthalene are the incomplete combustion of fossil fuels (e.g., coal) and tobacco smoke. DEET is an insect repellent that is commonly used against mosquitoes. It is available in several concentrations, ranging from 4% to 100%, and can be applied to clothing and skin. OPP is a disinfectant that is used topically on surfaces and as a fungicide for stored food crops. Hexachlorobenzene has also been used as a fungicide (see section titled "Organochlorine Pesticides" above). Exposure to these pesticides may also result from the ingestion of contaminated food products or from residential use. Workers involved in the manufacture, formulation, or application of these chemicals can be exposed as well.

Table 188 shows the various metabolites and their parent chemicals. The naphthalene metabolites, 1-naphthol and 2- naphthol, may result from exposure to naphthalene in old forms of mothballs, but exposure is more likely from sources of polycyclic aromatic hydrocarbons, such as tobacco smoke. In addition, carbaryl is metabolized to 1-naphthol (see section titled "Carbamates Pesticides" above). Thus, the presence of these metabolites in urine may reflect multiple sources of exposure. In addition to reflecting exposure to the parent chemical, the level of the metabolite in a person's urine may also reflect exposure to the metabolite if it was present in the person's environment.

Interpreting Urine Pest Repellent Levels Reported in the Tables

Urinary levels of the metabolites and the parent compounds of pest repellents were measured in a subsample of NHANES 1999-2000 participants aged 6 years and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. These samples were collected throughout the year and were not intended to reflect any pattern of seasonal use. Thus, samples may have been obtained during a seasonal period when the pest repellent was used less frequently.

Measuring these chemicals at these levels is possible because of advances in analytical chemistry. Finding a measurable amount of one or more metabolites in the urine does not identify the source of exposure, nor does it mean that the levels of the pest repellent cause an adverse health effect. Whether the chemicals at the levels reported here are causes for health concern is not known; more research is needed.

Generally recognized guidelines for urine levels of these metabolites have not been established. The FDA and OSHA have developed criteria on the allowable levels of these chemicals in foods and the workplace. The U.S. EPA has set similar criteria for water and for the storage and removal of waste (U.S. EPA*c*).

These data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of these chemicals than those

Table 188. Repellents or disinfectants and their urinary metabolites

Repellent or disinfectant (CAS number)	**Urinary metabolite** (CAS number)
Naphthalene (91-20-3)	1-Naphthol (90-15-3) 2-Naphthol (135-19-3)
p-Dichlorobenzene (DCB) (106-46-7)	2,5-Dichlorophenol (583-78-8)
N,N-diethyl-3-methylbenzamide (DEET) (134-62-3)	
ortho-Phenylphenol (90-43-7)	

found in the general population. These data will help scientists plan and conduct research about exposure to pest repellents and health effects.

2-Naphthol

CAS No. 135-19-3

Metabolite of naphthalene (CAS No. 91-20-3)

The 50th and 90th percentile levels for urinary 2-naphthol levels are lower than those values in a non-random subsample from NHANES III (1988-1994) (Hill et al., 1995). Geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary creatinine. The group aged 12-19 years had a slightly lower urine 2-naphthol level than the group aged 20 years and older. Urinary 2-naphthol levels among racial/ethnic or gender categories did not differ.

Table 189. 2-Naphthol

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	.471 (.327-.680)	< LOD	< LOD	.370 (<LOD-.740)	2.00 (1.10-3.30)	7.90 (4.00-12.0)	15.0 (9.90-19.3)	1993
Age group								
6-11 years	*	< LOD	< LOD	< LOD	1.50 (.470-2.70)	3.30 (2.00-5.30)	5.00 (3.50-11.0)	481
12-19 years	.423 (.279-.639)	< LOD	< LOD	.290 (<LOD-.630)	1.70 (.750-3.20)	5.80 (3.20-11.0)	9.80 (6.00-16.0)	681
20-59 years	.516 (.355-.751)	< LOD	< LOD	.450 (.200-.810)	2.20 (1.20-3.70)	9.90 (4.30-15.0)	15.0 (11.0-23.0)	831
Gender								
Males	.502 (.335-.752)	< LOD	< LOD	.420 (<LOD-.950)	2.00 (1.20-3.50)	9.40 (4.10-14.5)	15.0 (9.90-22.0)	973
Females	.444 (.304-.647)	< LOD	< LOD	.330 (<LOD-.660)	1.50 (.810-3.30)	6.60 (3.60-12.0)	13.0 (8.30-21.0)	1020
Race/ethnicity								
Mexican Americans	.557 (.379-.819)	< LOD	< LOD	.530 (.260-1.10)	1.90 (1.10-3.60)	5.00 (3.30-8.30)	9.60 (5.50-18.0)	696
Non-Hispanic blacks	.801 (.476-1.35)	< LOD	< LOD	.740 (.310-1.50)	3.70 (1.50-7.50)	14.0 (5.60-23.0)	24.0 (15.0-31.0)	520
Non-Hispanic whites	*	< LOD	< LOD	.300 (<LOD-.650)	1.50 (.810-2.90)	6.50 (3.00-15.0)	14.5 (6.50-24.0)	602

< LOD means less than the limit of detection, which is 0.2 µg/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 190. 2-Naphthol (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	.421 (.297-.596)	< LOD	< LOD	.338 (.196-.625)	1.56 (.964-2.65)	5.98 (3.25-9.46)	10.8 (6.53-16.0)	1993
Age group								
6-11 years	*	< LOD	< LOD	< LOD	1.63 (.533-2.69)	2.94 (2.24-3.55)	3.57 (3.11-9.36)	481
12-19 years	.285 (.194-.420)	< LOD	< LOD	.206 (.115-.435)	.979 (.503-1.81)	3.47 (1.60-5.58)	5.37 (3.58-8.43)	681
20-59 years	.474 (.332-.677)	< LOD	< LOD	.412 (.247-.681)	1.68 (1.03-3.18)	6.79 (4.25-10.8)	14.7 (8.41-17.6)	831
Gender								
Males	.385 (.262-.565)	< LOD	< LOD	.332 (.163-.618)	1.36 (.894-2.72)	5.13 (3.02-10.0)	10.9 (5.58-17.2)	973
Females	.460 (.325-.652)	< LOD	< LOD	.339 (.206-.652)	1.65 (.988-2.80)	6.25 (3.18-9.63)	9.64 (6.03-16.5)	1020
Race/ethnicity								
Mexican Americans	.501 (.337-.744)	< LOD	< LOD	.445 (.250-.909)	1.61 (.833-2.91)	4.24 (2.66-6.67)	6.79 (4.34-10.3)	696
Non-Hispanic blacks	.543 (.329-.897)	< LOD	< LOD	.467 (.199-1.21)	2.11 (1.10-4.81)	8.16 (4.05-11.0)	11.0 (8.16-15.2)	520
Non-Hispanic whites	*	< LOD	< LOD	.308 (.171-.596)	1.38 (.833-2.64)	5.98 (2.68-11.0)	13.2 (5.37-17.6)	602

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

2,5-Dichlorophenol

CAS No. 583-78-8

Metabolite of p-dichlorobenzene (CAS No. 106-46-7)

In a non-random subsample from NHANES III, the median level of 2,5-dichlorophenol was 30 µg/L, (Hill et al., 1995), which is about five times higher than the median shown in this *Report*. Angerer et al. (1992) measured 2,5-dichlorophenol in the urine of municipal waste-incinerator workers and reported a median level similar to the median in the adults documented in this *Report*.

Geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary creatinine. Urinary 2,5-dichlorophenol levels in the 6-11-year-old group were higher than in the 12-19-year-old group. Non-Hispanic blacks and Mexican Americans had levels of 2,5-dichlorophenol that were two to three times higher than levels in non-Hispanic whites.

Table 191. 2,5-Dichlorophenol

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	6.01 (4.22-8.57)	< LOD	1.40 (.710-2.10)	6.50 (4.60-9.90)	37.8 (23.0-52.0)	144 (88.0-240)	440 (240-700)	1989
Age group								
6-11 years	7.57 (4.26-13.5)	< LOD	1.60 (.620-3.10)	9.00 (4.30-15.0)	46.0 (20.0-130)	240 (87.0-640)	630 (230-760)	480
12-19 years	5.85 (3.88-8.81)	< LOD	1.70 (.780-2.60)	4.80 (3.80-7.60)	32.0 (18.0-45.0)	130 (70.0-250)	382 (170-820)	680
20-59 years	5.82 (4.04-8.40)	< LOD	1.30 (.610-2.00)	6.60 (4.60-11.0)	36.7 (21.0-51.0)	130 (83.0-200)	420 (200-660)	829
Gender								
Males	6.84 (4.95-9.47)	< LOD	1.70 (1.30-2.70)	7.90 (5.68-11.0)	37.0 (24.0-52.0)	150 (98.0-240)	440 (195-590)	970
Females	5.30 (3.31-8.51)	< LOD	1.00 (.350-2.00)	5.40 (3.30-9.80)	37.8 (18.0-57.0)	150 (75.0-290)	490 (200-850)	1019
Race/ethnicity								
Mexican Americans	14.3 (7.13-28.5)	< LOD	3.30 (.970-7.20)	13.0 (8.00-24.0)	110 (45.0-270)	660 (280-1000)	1100 (650-2400)	695
Non-Hispanic blacks	15.8 (9.83-25.4)	< LOD	4.30 (1.60-8.30)	19.0 (11.0-32.0)	110 (54.0-180)	460 (241-704)	770 (470-1100)	517
Non-Hispanic whites	3.81 (2.66-5.44)	< LOD	1.10 (.230-1.80)	4.40 (3.00-5.90)	19.0 (12.0-33.0)	75.0 (47.0-130)	170 (98.0-550)	602

< LOD means less than the limit of detection, which is 0.1 µg/L.

Table 192. 2,5-Dichlorophenol (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	5.38 (3.86-7.49)	< LOD	1.29 (.857-2.06)	5.60 (4.11-8.16)	26.0 (16.9-41.1)	125 (68.8-216)	299 (226-458)	1989
Age group								
6-11 years	8.17 (4.64-14.4)	< LOD	1.88 (.943-3.07)	11.3 (4.79-21.0)	47.7 (22.4-100)	247 (80.8-473)	516 (267-762)	480
12-19 years	3.95 (2.59-6.02)	< LOD	1.19 (.500-2.20)	4.11 (2.60-6.08)	19.4 (12.1-31.7)	64.7 (47.1-196)	233 (151-398)	680
20-59 years	5.36 (3.87-7.41)	< LOD	1.23 (.749-1.95)	5.60 (4.11-8.41)	24.5 (15.1-40.6)	115 (64.5-209)	280 (216-509)	829
Gender								
Males	5.25 (3.84-7.18)	< LOD	1.49 (.974-2.09)	5.44 (4.11-7.48)	24.1 (15.4-32.1)	96.8 (64.5-213)	289 (213-432)	970
Females	5.50 (3.58-8.46)	< LOD	1.17 (.496-2.27)	6.15 (3.97-9.87)	28.9 (15.1-50.0)	136 (68.1-216)	352 (216-644)	1019
Race/ethnicity								
Mexican Americans	12.9 (6.53-25.4)	< LOD	2.97 (1.01-6.10)	12.7 (7.24-26.2)	72.7 (34.1-200)	515 (200-1170)	1170 (580-2790)	695
Non-Hispanic blacks	10.7 (6.93-16.7)	< LOD	3.29 (1.52-5.10)	13.5 (8.10-22.1)	57.8 (32.2-97.4)	241 (124-339)	433 (245-746)	517
Non-Hispanic whites	3.60 (2.56-5.06)	< LOD	.944 (.368-1.53)	3.81 (2.84-4.90)	14.4 (9.86-21.7)	57.4 (35.0-136)	202 (88.8-355)	602

< LOD means less than the limit of detection (see previous table).

N,N-diethyl-3-methylbenzamide

CAS No. 134-62-3

N,N-diethyl-3-methylbenzamide (DEET) is an insect repellent that was first marketed in 1957. It is commonly used against mosquitoes and can be applied to clothing and the skin. The annual use of DEET in the total U.S. population is estimated at 30% and among children at 34% (U.S. EPA*d*, 1980). Commercial DEET ranges in concentration from 4% to 100% (95% m-DEET, 5% o-DEET and p-DEET). The o- and p-DEET isomers are byproducts of manufacturing. The isomers differ in toxicity and their effectiveness as repellents; m-DEET is most effective as a repellent and o-DEET may be more toxic (Ambrose and Yost, 1965). When applied to the skin, DEET is absorbed and eliminated primarily in the urine.

The general population may be exposed to DEET from the ingestion of contaminated food or from personal use. Workers involved in the manufacture, formulation, or application of these chemicals can be exposed as well. People in occupations involving increased outdoor activity (e.g., field biologists, military personnel) may have additional exposure to DEET from increased use (Robbins and Cherniack, 1986). Urinary m-DEET levels as high as 5,690 ug/L have been measured in eight park employees who applied 71% m-DEET once a day (Smallwood et al., 1992).

Table 193. N,N-diethyl-3-methylbenzamide (DEET)

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1977
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	480
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	672
20-59 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	825
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	964
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1013
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	688
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	518
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	597

< LOD means less than the limit of detection, which averaged .06 µg/L (SD .13, maximum value 0.45).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 194. N,N-diethyl-3-methylbenzamide (DEET) (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1977
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	480
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	672
20-59 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	825
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	964
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1013
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	688
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	518
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	597

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

ortho-Phenylphenol

CAS No. 90-43-7

General Information

Ortho-phenylphenol (OPP) and its water soluble salt, sodium *o*-phenylphenate (SOPP), are pesticides used agriculturally to control fungal and bacterial growth on stored crops (e.g,. fruits, vegetables). These agents came into use in the mid 1930s. SOPP is applied topically to the crop and then rinsed off, leaving the chemical residue, *o*-phenylphenol. OPP offers additional protection to the crop from infection at scarred or injured sites (Johnson et al., 2001). OPP is also used as a disinfectant fungicide for industrial and indoor home use.

The general population may be exposed to these chemicals from residential use and by ingesting treated food or contaminated ground water. Workers who manufacture, formulate, or apply these chemicals may be exposed to them as well. The major urinary metabolites from SOPP exposure are OPP glucuronide and sulfate conjugates. IARC has classified SOPP as a possible human carcinogen and OPP as not classifiable as a human carcinogen. The NTP conducted a 2-year experimental animal dermal study using OPP and found no evidence of carcinogenicity. The effects on the general population at the current level of exposure are not yet known. Further research is needed.

Table 195. *ortho*-Phenylphenol

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	.494 (.412-.593)	< LOD	< LOD	.490 (.300-.590)	.850 (.650-1.10)	1.46 (1.10-1.80)	2.00 (1.60-2.50)	1991
Age group								
6-11 years	.506 (.419-.613)	< LOD	< LOD	.490 (<LOD-.580)	.890 (.670-1.30)	1.80 (1.40-2.10)	2.20 (1.90-3.30)	480
12-19 years	.506 (.400-.640)	< LOD	< LOD	.490 (<LOD-.600)	.890 (.640-1.30)	1.60 (1.20-2.10)	2.00 (1.40-6.30)	681
20-59 years	.489 (.408-.587)	< LOD	< LOD	.490 (.300-.600)	.810 (.630-1.10)	1.41 (1.10-1.70)	1.90 (1.60-2.50)	830
Gender								
Males	.495 (.412-.595)	< LOD	< LOD	.460 (<LOD-.570)	.820 (.660-1.20)	1.60 (1.20-1.90)	1.90 (1.60-2.90)	973
Females	.493 (.405-.600)	< LOD	< LOD	.480 (<LOD-.580)	.860 (.620-1.10)	1.50 (1.10-1.80)	2.10 (1.60-2.40)	1018
Race/ethnicity								
Mexican Americans	.548 (.406-.739)	< LOD	< LOD	.410 (<LOD-.790)	1.10 (.660-1.60)	2.20 (1.50-4.10)	3.80 (2.40-6.70)	695
Non-Hispanic blacks	.562 (.443-.715)	< LOD	< LOD	.560 (.440-.740)	.970 (.730-1.40)	1.60 (1.30-1.80)	1.90 (1.50-2.30)	520
Non-Hispanic whites	.463 (.373-.575)	< LOD	< LOD	.440 (<LOD-.570)	.760 (.580-1.10)	1.40 (.980-1.70)	1.90 (1.50-2.50)	602

< LOD means less than the limit of detection, which is 0.3 µg/L.

Interpreting Urine ortho-Phenylphenol (OPP) Levels Reported in the Tables

Urine levels of OPP were measured in a subsample of NHANES 1999-2000 participants aged 6 years and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. Measuring these chemicals at these levels is possible because of advances in analytical chemistry. Finding a measurable amount of OPP in the urine does not identify the source of exposure, nor does it mean that the level of OPP causes an adverse health effect. Whether OPP at the levels reported here is a cause for health concern is not known; more research is needed.

These data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of OPP than those found in the general population. These data will help scientists plan and conduct research on exposure to sodium *o*-phenyl phenol and their health effects.

Generally recognized guidelines for urine levels have not been established. There were no differences found among the demographic age, race/ethnicity, or gender groups.

Table 196. *ortho*-Phenylphenol (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	.441 (.369-.528)	< LOD	< LOD	.413 (.328-.524)	.840 (.660-1.07)	1.84 (1.31-2.21)	2.93 (2.14-3.89)	1991
Age group								
6-11 years	.547 (.470-.636)	< LOD	< LOD	.504 (.413-.636)	1.02 (.800-1.27)	1.96 (1.51-2.57)	2.61 (2.09-3.58)	480
12-19 years	.342 (.270-.432)	< LOD	< LOD	.319 (.218-.430)	.691 (.505-.877)	1.14 (.889-1.70)	1.96 (1.19-3.95)	681
20-59 years	.450 (.373-.542)	< LOD	< LOD	.420 (.325-.538)	.861 (.656-1.09)	1.89 (1.35-2.24)	3.28 (2.21-4.29)	830
Gender								
Males	.379 (.315-.457)	< LOD	< LOD	.353 (.258-.444)	.752 (.589-.943)	1.43 (1.09-1.82)	2.07 (1.65-3.11)	973
Females	.511 (.423-.619)	< LOD	< LOD	.459 (.400-.577)	.909 (.732-1.24)	2.04 (1.51-2.59)	3.78 (2.29-4.95)	1018
Race/ethnicity								
Mexican Americans	.492 (.353-.686)	< LOD	< LOD	.420 (.250-.696)	1.11 (.659-1.62)	2.99 (1.37-4.60)	4.61 (3.00-10.0)	695
Non-Hispanic blacks	.382 (.302-.482)	< LOD	< LOD	.375 (.288-.494)	.672 (.534-.859)	1.21 (.860-1.65)	1.69 (1.23-3.17)	520
Non-Hispanic whites	.438 (.350-.547)	< LOD	< LOD	.410 (.301-.568)	.861 (.627-1.11)	1.86 (1.24-2.29)	2.93 (2.03-3.90)	602

< LOD means less than the limit of detection (see previous table).